

# **Linear Collider Detector R&D at Fermilab**

*Physics Advisory Committee*

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*For the Fermilab ILC Detector Group*

**Fermilab**  
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# Goals and Approach

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- **Goals:**

- **Establish a coherent, focused ILC Detector R&D program at Fermilab**
- **Focus on critical detector R&D areas**
- **Tie in, and help define, future activities and strengths across the laboratory and across the ILC community**

- **Approach:**

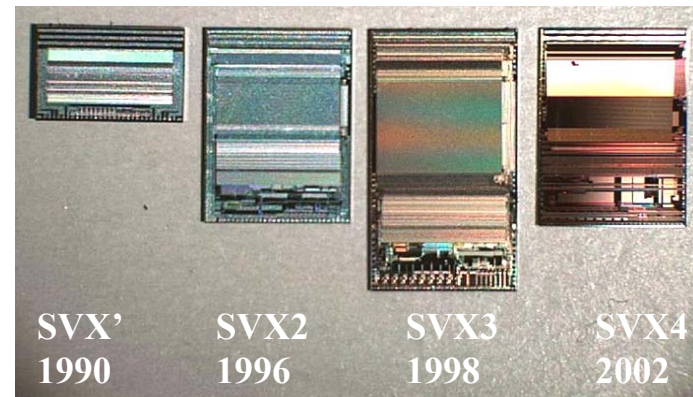
- **Identify areas of strengths at the laboratory**
- **Identify areas of synergy between existing Fermilab projects and ILC**
- **Identify areas unique to the laboratory**
- **Exploit regional common interests**
- **Form collaborative efforts where possible**
- **When possible, keep R&D general, not detector specific**

- **Documentation:**

- **<http://ilc.fnal.gov/detector/rd/detrd.html>**

# Laboratory Strengths

- **Silicon Expertise, both strips and pixels**
  - **Design and construction of vertex detectors:**
    - CDF: SVX, SVX', SVXII, Layer 00, (ISL)
    - DØ: SMT, SMT', Layer 0
    - BTeV: Strip, Pixels
    - CMS: Forward Pixels (Strips)
  - **Front-end and back-end Readout**
    - ASIC design: SVX, SVX', SVX2, SVX3, SVX4, FSSR, FPIX, .....
    - Hybrid design, sequencer boards, ...
  - **Infrastructure: SiDet**
- **Silicon readout:**
  - **Strong Fermilab CMS tracking group**
  - **Fermilab CMS XDAQ group being formed**
- **Superconducting magnets**
- **Test Beams**
- **Strong support role from Computing Division**
  - **Data acquisition systems, simulations, GEANT4, ...**
- **Beam delivery and beam induced backgrounds**
- **Overlapping physics fundamentals: particle production (MIPP, MINOS, ...) and physics analyses strengths**



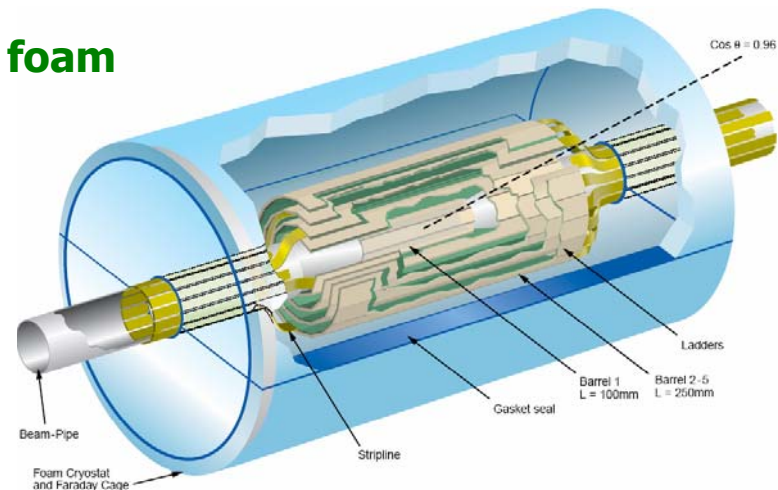
# World Wide Study R&D Panel

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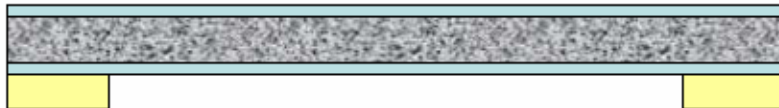
- The World Wide Study Organizing Committee has established the Detector R&D Panel to promote and coordinate detector R&D for the ILC
  - <https://wiki.lepp.cornell.edu/www/bin/view/Projects/WebHome>
- Fermilab has nine submissions to this registry:
  - **Vertex and Tracking detectors:**
    - Mechanical design of vertex detector ..... RD1
    - Active Pixels ..... RD2
      - MAPS ..... RD3a
      - SOI and 3D ..... RD3b
    - Hybrid Pixels ..... RD4
    - Beam pipe design ..... RD5
  - **Calorimetry:**
    - Particle-Flow Algorithms and Related Simulation Software ..... RD6
    - Digital Hadron Calorimeter with RPC's ..... RD7
  - **5T Solenoid design** ..... RD8
  - **Scintillator-Based Muon System R&D** ..... RD9

# Low Mass Vertex Detectors: RD1

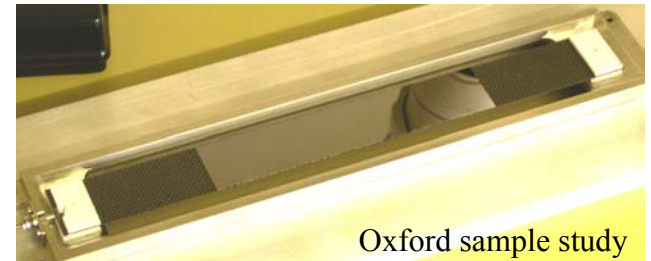
- **Multi-layered, high precision, very thin, low mass detectors**
  - Layer thickness of  $0.1\% X_0$  per layer, equivalent of  $100\text{ }\mu\text{m}$  of Si
  - High granularity:  $5 - 20\text{ }\mu\text{m}$  pixels;  $10^9$  pixels for barrel detector
  - Radiation tolerant
- **Mechanical aspects: reduce mass using alternate materials**
  - 8% Silicon Carbide Foam
  - 3% Reticulated Vitreous Carbon (RVC) foam
  - Collaborate with SLAC, Rutherford



RVC foam (foam thickness 1.5 mm)



Silicon Carbide foam (foam thickness 1.5 mm)



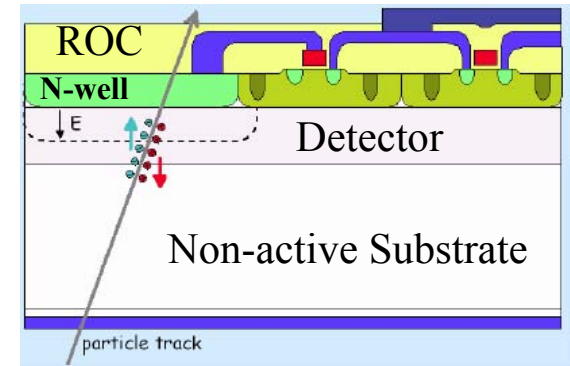
# Low Mass Vertex Detectors

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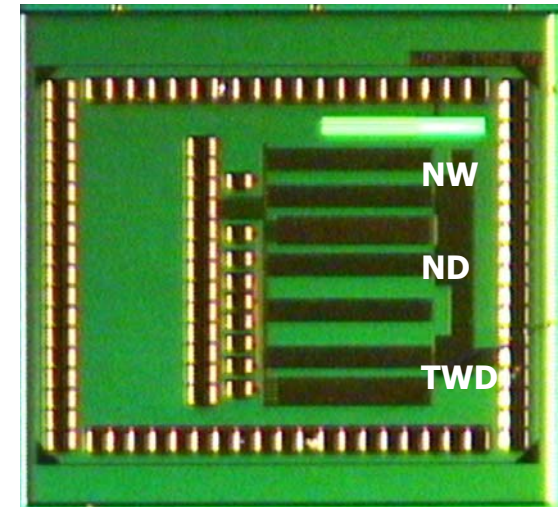
- **To obtain required low mass, concurrent efforts needed addressing electrical aspects:**
  - **Reduce power so less mass is needed to extract heat**
    - Digital power: drive at lower voltage (smaller feature size processes)
    - Analogue power: power pulsing
  - **Alternatives**
    - MAPS
    - SOI, 3D
    - Thin Si
- **Many of the open issues for use of this technology as particle detectors are shared with industry**
  - **Improve charge sensing system**
  - **Control of epitaxial layer; number of metal layers**
  - **number and size of capacitors per pixel**
  - **Fast readout and fast signal processing; low power consumption**
  - **Small and 'massless'; operation at room temperature**
  - **Radiation tolerant**

# Monolithic Active Pixel Sensors

- A MAPS device is a silicon structure where the detector and the primary readout electronics are processed on the same substrate
- MAPS can be divided into two classifications:
  - Those using standard CMOS processes
  - Those using specialized processes
- As introduction into this area submitted a 130 nm chip in IBM CMOS process to study characteristics:
  - Feature devices on chip
    - Registers for SEU evaluation
    - LVDS drivers
    - Test devices
  - Pixel layout
    - 80 row x 3 column pixel readout array
      - Column with no diodes
      - Column with N-well
      - Column with triple N-well
    - Fine pitch readout circuit:  $10 \times 340 \mu\text{m}$
    - Fine pitch diodes,  $10 \times 150 \mu\text{m}$ , connected to readout circuits
  - In process of characterizing performance



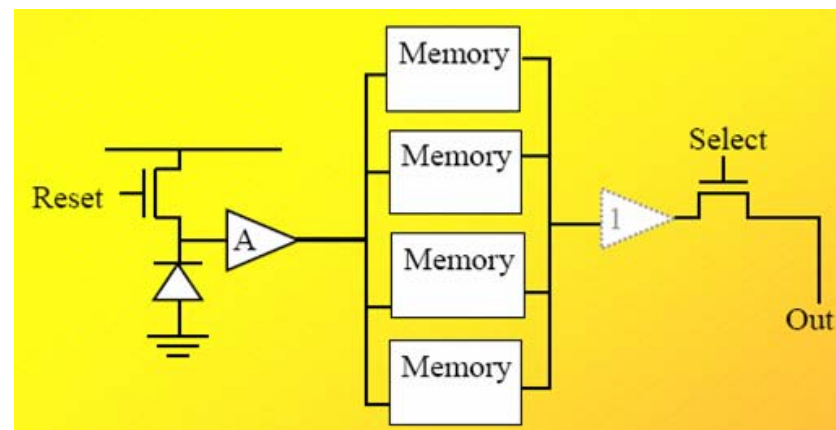
MAPS Principle



3x80 pixel array

# Standard CMOS MAPS: RD2

- RD2: MAPS with epi-layer
- Basic architecture is 3 transistor cell
  - signal created in epitaxial layer
  - thermal charge collection (no HV)
  - charge sensing through n-well/p-epi junction

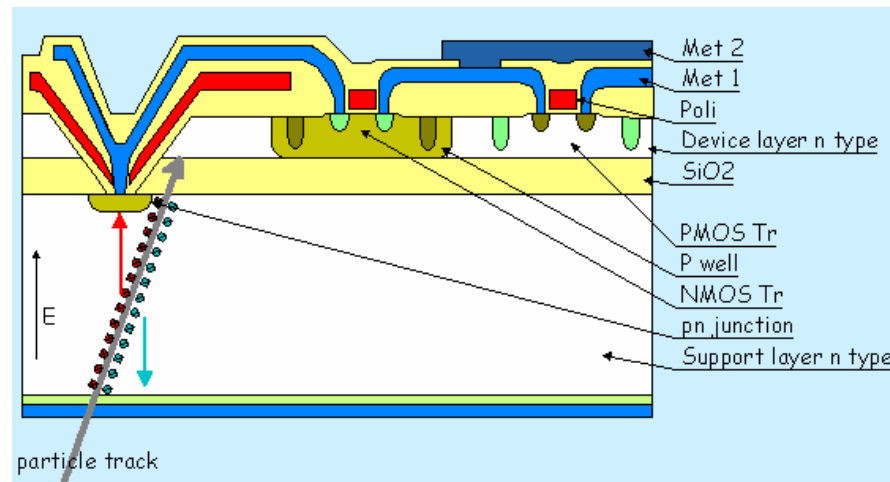


- Development for Super-Belle; current version (Gary Varner, Hawaii):
  - pixel size:  $20 \times 20 \mu\text{m}^2$ ; 36 transistors/pixel; 5 metal layers; TSMC  $0.25 \mu\text{m}$  process
  - $128 \times 928$  pixels/sensor; double pipe-line 5 deep
  - Double correlated sampling with reset in abort gaps (500ns every  $10 \mu\text{s}$ )
  - Column select readout,  $10 \mu\text{s}$  frame readout
  - $\text{Signal} \sim 300e^-$ ,  $\text{Noise} \sim 20\text{-}35e^- \rightarrow \text{S/N} \sim 10\text{-}15$
- Starting collaboration with Hawaii (Gary Varner), IReS (Marc Winter) and discussions with Bergamo (Valerio Re)
  - Challenges
    - Many newer processes have thinner or no epi: very small signals
    - Readout speed, transistor options are limited
    - Radiation hardness, thinning

# Silicon On Insulator: RD3a

- **Silicon on Insulator (SOI)**

- **Non-standard process**
- **Handle wafer, normally passive is the detector**
- **Signal collected in fully depleted substrate, thus large signals**
- **Electronics in the device layer**
- **Should be rad. hard; can have NMOS and PMOS transistors**

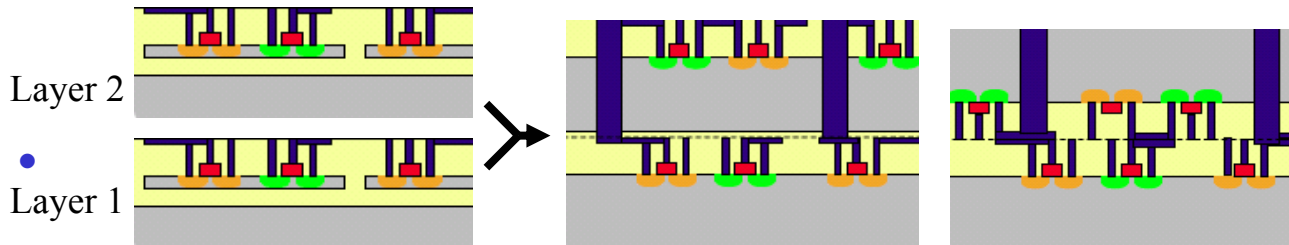
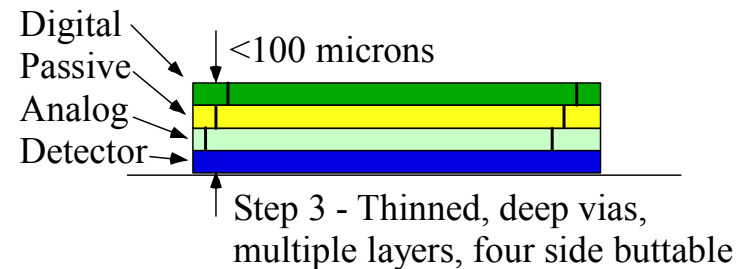
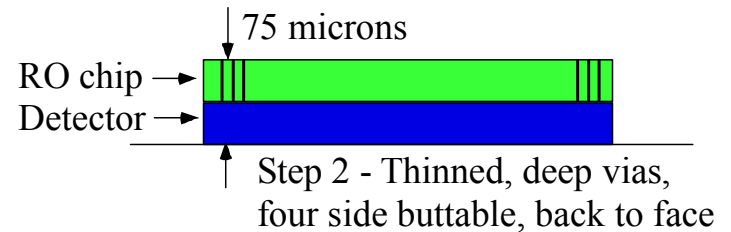
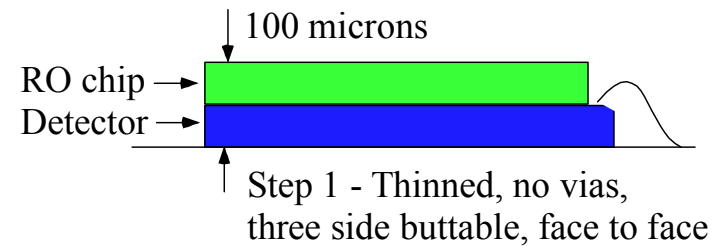


- **Process Technology**

- **Allows for production of pixel sensors which are thin (<50 microns)**
- **Excellent and well controlled charge collection using fully depleted devices**
- **Use full CMOS readout without parasitic charge collection**
- **High-resistivity handle wafer as detector**

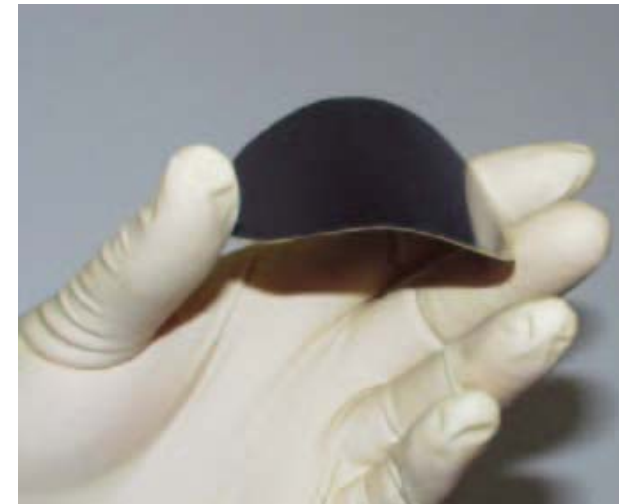
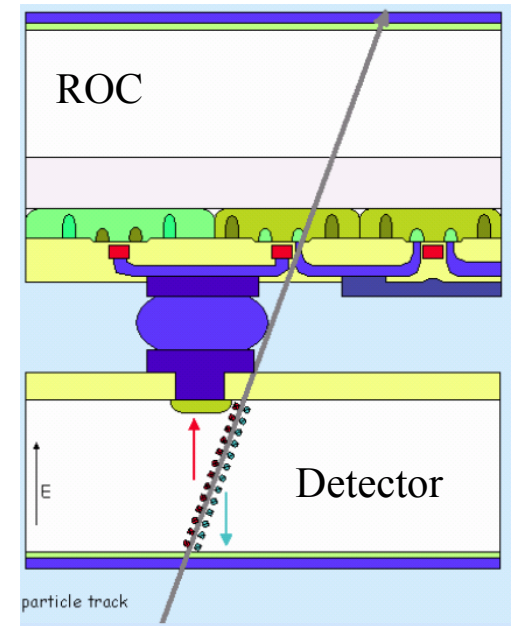
# 3D Process: RD3b

- A 3D device is a chip comprised of 2 or more layers of semiconductor devices which have been thinned, bonded, and interconnected to form a monolithic circuit
  - Layers can have devices made in different technologies
    - Process optimization for each layer
- Direction in industry
  - Early push for device scaling, circuit integration and packaging density
  - Interconnect and packaging issues are real barriers
  - Push towards planar approach: 3D
- Critical issue is thinning and bonding of the various layers



# Hybrid Pixel Detectors: RD4

- Hybrid pixel detectors have separate detector and readout chip, connected by bump bond
  - sensor and read-out chip (roc) can be optimized separately
- Continuing issues with this technology:
  - cooling of detectors under high radiation
  - mass and cost
- Using the existing BTeV sensors and FPIX readout chip to study:
  - Thinning of roc down to  $80\ \mu\text{m}$ , bump bonded to BTeV sensors
    - ALICE thinned down to  $150\ \mu\text{m}$
  - Thinned roc's bump bonded to new thin BTeV sensors
  - Power management and cooling requirements adequate for gas cooling of the hybrids with an ILC bunch structure
  - Efficiency, time resolution, readout speed, zero-suppressed readout.



# Beam Pipe Design: RD5

- Beryllium beam pipe with conical shape beyond the central region to avoid pair background;

- Specifications:

- Central section

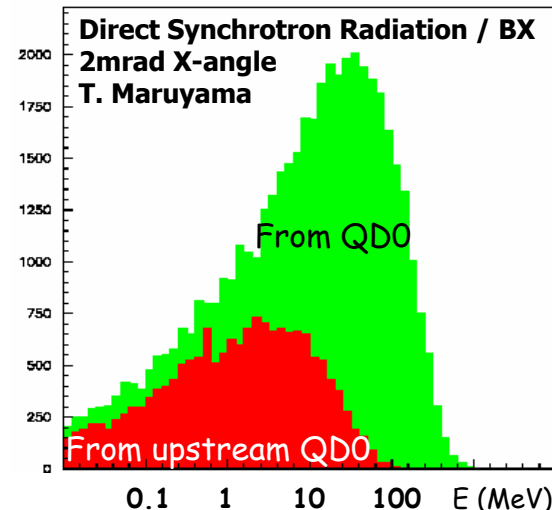
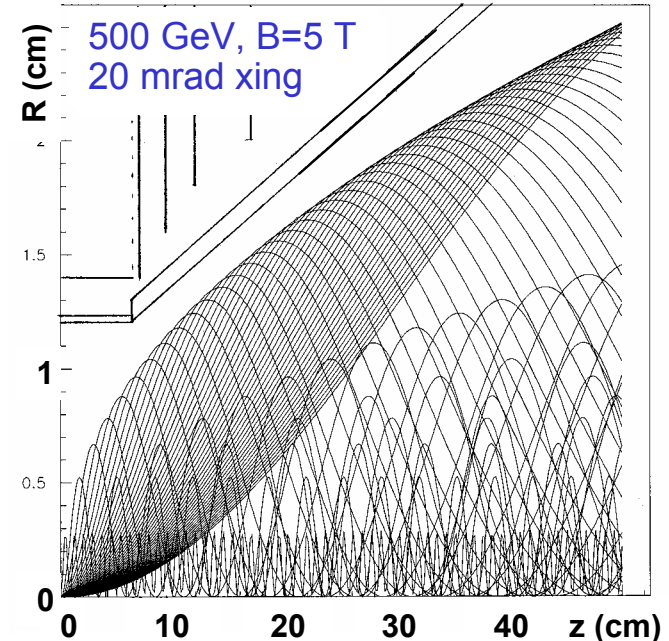
- Inner radius of 12 mm, length 135 mm
    - Wall thickness of  $250 \pm 15 \mu\text{m}$
    - No collapse under vacuum, no porosity

- Conical section

- Half length of  $\sim 3\text{m}$ ; inner radius increases to  $\sim 150\text{ mm}$
    - Increasing wall thickness:  $\partial t / \partial R = 14 \mu\text{m/mm}$  (at  $z=3\text{m}$ ,  $t=2\text{mm}$ )
    - Transition using electron beam brazing technique

- Liner

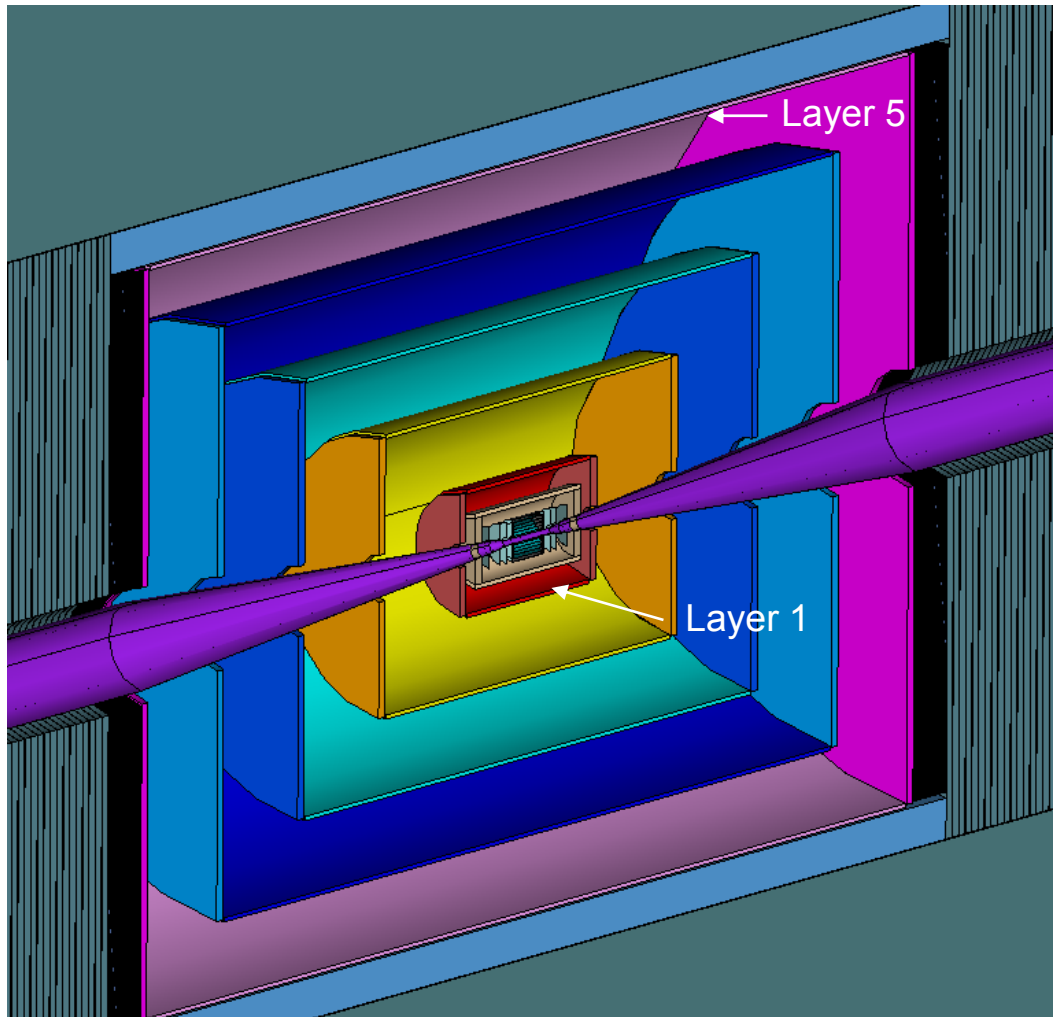
- To absorb X-ray photons from radiation: 25 (75)  $\mu\text{m}$  Titanium (Au?) liner for central (conical) section
    - electrically integrated with Be beam pipe (plated)



T. Maruyama

# Outer Tracker Design

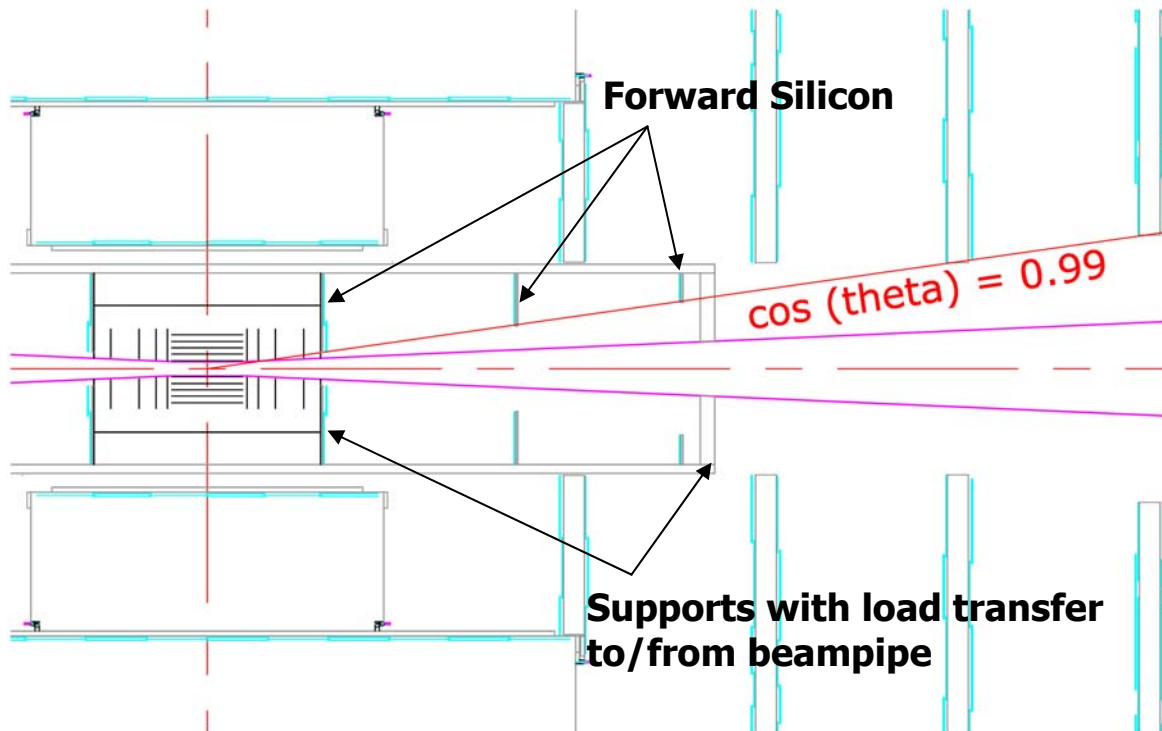
- Early this year completed 5-Layer silicon strip outer tracker design, covering  $R_{in} = 20\text{ cm}$  to  $R_{out} = 125\text{ cm}$



- **Support**
  - Double-walled CF cylinders
  - Allows full azimuthal and longitudinal coverage
- **Barrels**
  - Five barrels, measure Phi only
  - Eighty-fold phi segmentation
  - 10 cm z segmentation
  - Barrel lengths increase with radius
- **Disks**
  - Five double-disks per end
  - Measure R and Phi
  - varying R segmentation
  - Disk radii increase with Z

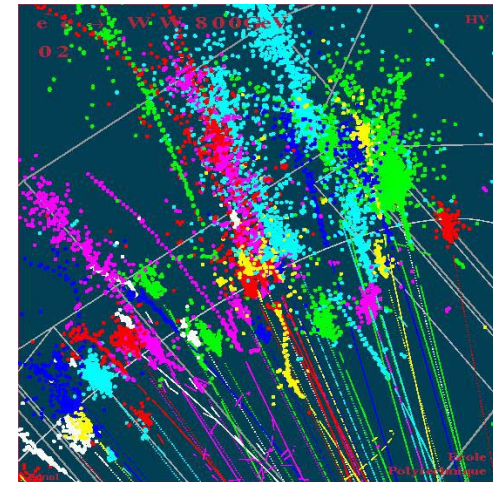
# Vertex and Tracker Integration

- Started on integrated tracker, vertex detector, beampipe design (RD1+RD5)
- Forward tracking elements are integral part of inner tracking assembly
- Vertex detector and forward tracking assembly installed on beam pipe
  - Support structures are based upon half-cylinders
  - Outer support half-cylinders could be thermally insulating
  - Detector elements are supported from those half-cylinders
  - Support half-disks couple to the beam pipe at  $z \sim \pm 0.2 \text{ m} / \pm 0.9 \text{ m}$



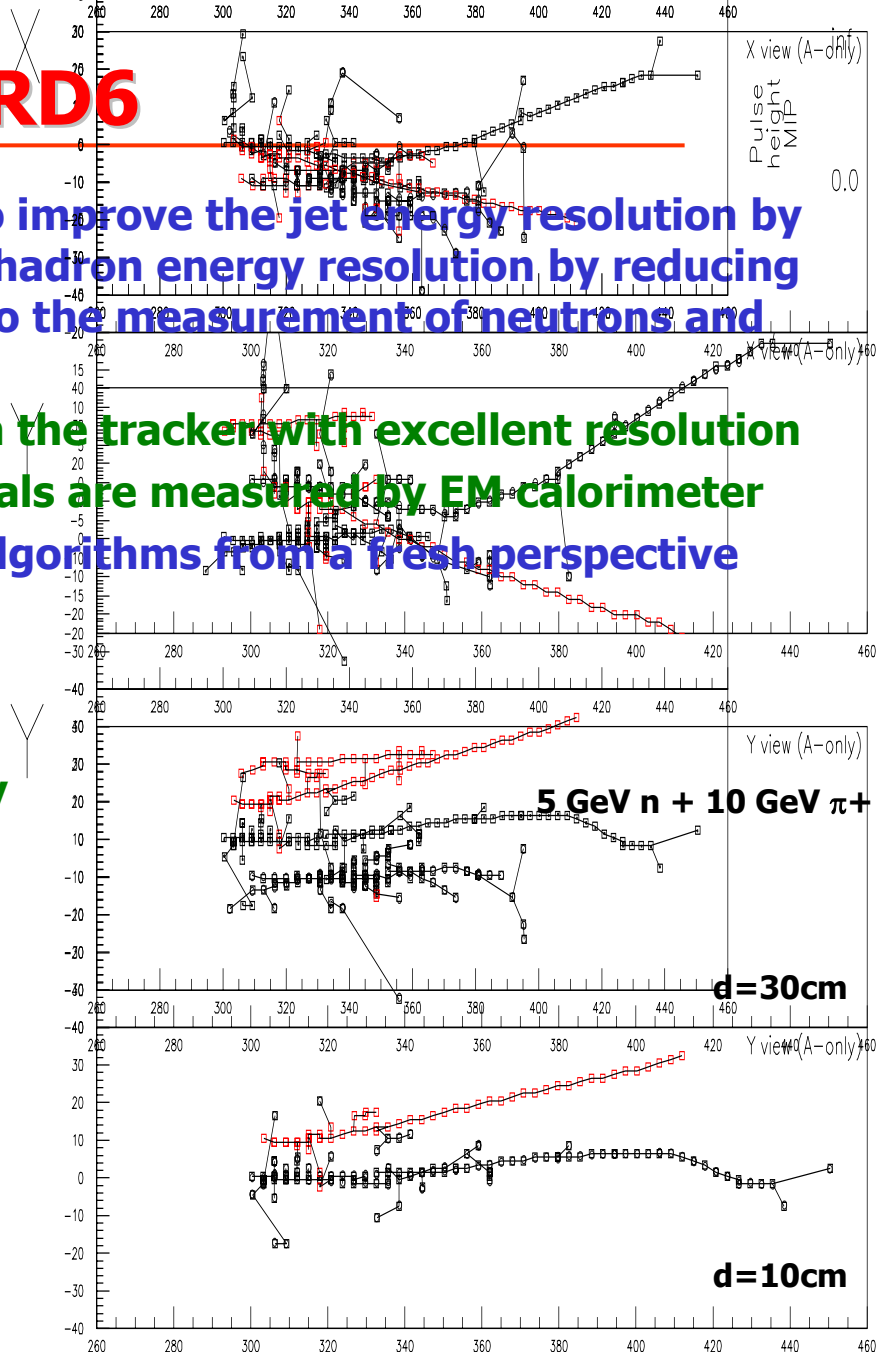
# Calorimetry

- **Demonstration of Particle Flow Algorithm (PFA) achieving energy resolution required for ILC physics (separation of W/Z in hadronic decays) is critical**
  - **Calorimeters with unprecedented longitudinal and transverse granularity**
- **Technology options**
  - **Active medium: Si, scintillator, RPC, GEM**
  - **Readout: digital, analogue**
  - **Clustering algorithms: identifying neutrals**
- **At Fermilab**
  - **Working within regional focus group**
    - Argonne (RPC digital HCAL)
    - NIU (scintillator analogue HCAL, tailcatcher)
    - UofC (HCAL readout)
  - **Technology neutral position**
  - **PFA from the perspective of hadronic shower development**



# PFA: RD6

- A particle flow algorithm is a recipe to improve the jet energy resolution by minimizing the contribution from the hadron energy resolution by reducing the function of a hadron calorimeter to the measurement of neutrons and  $K^0$ 's only
  - Charged particles are measured in the tracker with excellent resolution
  - Electromagnetic showers of neutrals are measured by EM calorimeter
- Look at particle flow and associated algorithms from a fresh perspective
  - Figure of merit for PFA's
    - decouple linearity, EM/HAD response, calibrations
  - Fundamental limitations of energy resolution
- New approach to algorithm
  - currently 'agglomerative' algorithms
    - clusters are grown
  - Alternative 'divisive' algorithm
    - Utilizes global event; split up in clusters



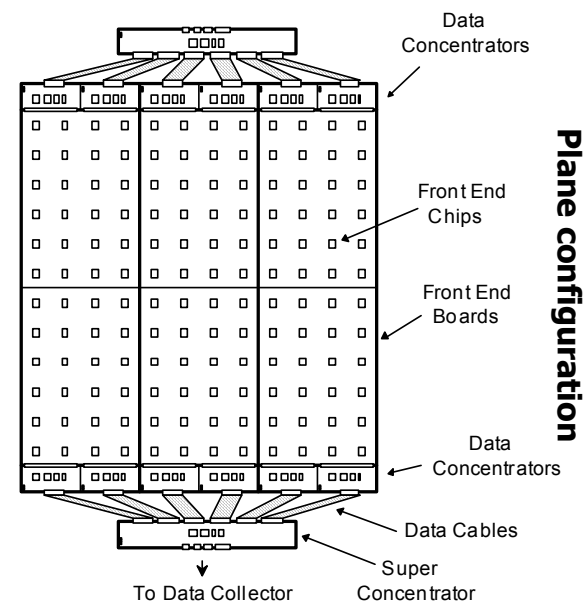
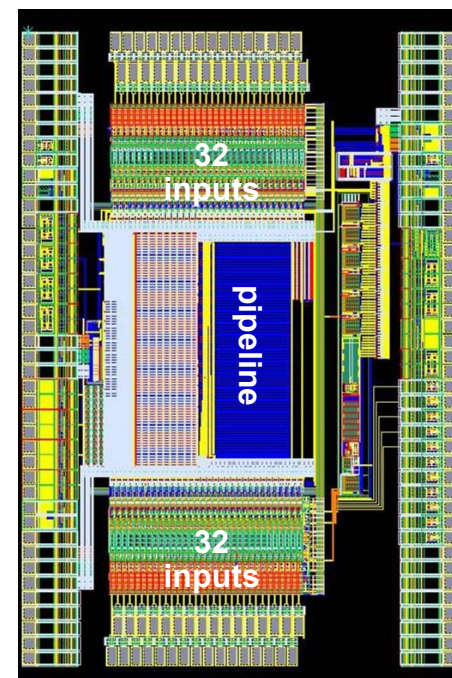
# Calorimeter Readout: RD7

- **Readout chip for Digital HCAL (in CALICE framework)**  
**Prototype chip in hand**

- **For Fermilab testbeam in 2007 to prove DHCAL concept**
- **1 m<sup>3</sup>, 400,000 channels, with RPC's and GEM's**
  - 64 channels/chip; 1 cm x 1 cm pads
  - Detector capacitance: 10 to 100 pF
  - Smallest input signals: 100 fC (RPC), 5 fC (GEM)
  - Largest input signals: 10 pC (RPC), 100 fC (GEM)
  - Adjustable gain; Signal pulse width 3-5 ns
  - Trigger-less or triggered operation
  - 100 ns clock cycle
  - Serial output: hit pattern + timestamp

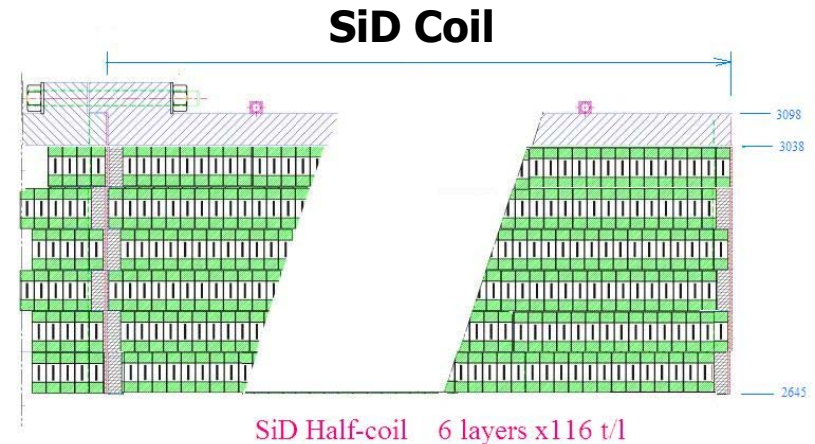
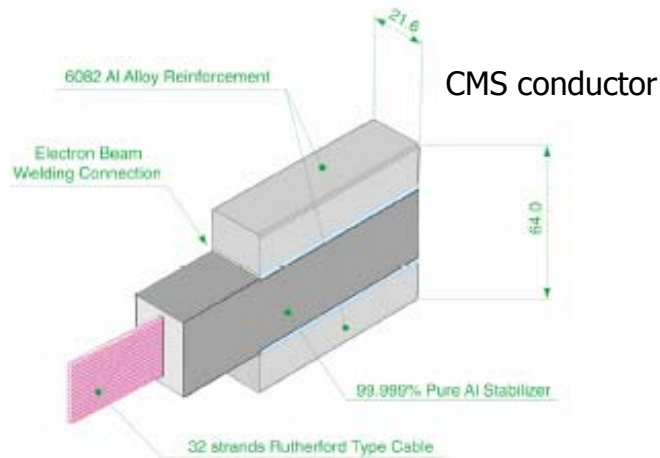
- **Front-end motherboard**

- **Multi-Layer PCB that hosts asics (ANL)**
  - Cell structure incorporated in board
- **Data concentrator (ANL)**
- **Super concentrator (UofC ?)**
- **Data collector (BU)**



# Solenoid: RD8

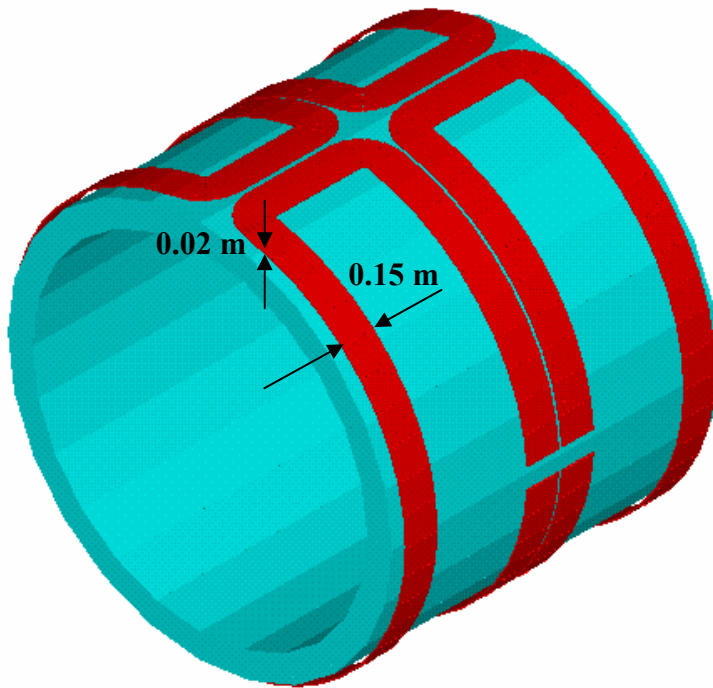
- **Design of solenoid with  $B(0,0) = 5\text{T}$  (not done previously)**
  - **Clear Bore  $\varnothing \sim 5\text{ m}$ ;  $L = 5.4\text{ m}$ : Stored Energy  $\sim 1.2\text{ GJ}$** 
    - For comparison, CMS: 4 T,  $\varnothing = 6\text{m}$ ,  $L = 13\text{m}$ : 2.7 GJ



- **Full feasibility study (with CERN, Saclay) of design based on CMS conductor**
  - **Start with CMS conductor design, but increase winding layers from 4 to 6**
    - $I(\text{CMS}) = 19500\text{ A}$ ,  $I(\text{SiD}) = 18000\text{ A}$ ; Peak Field (CMS) 4.6 T, (SiD) 5.8
    - Net performance increase needed from conductor is modest
- **Collaborating with CERN on new conductor tests**
  - **34 strands of NbTi to 36 strands; test at the 20kA, 4-6 Tesla scale**
  - **Hardening of the high purity aluminum with specific alloys to improve behavior in high stress conditions**

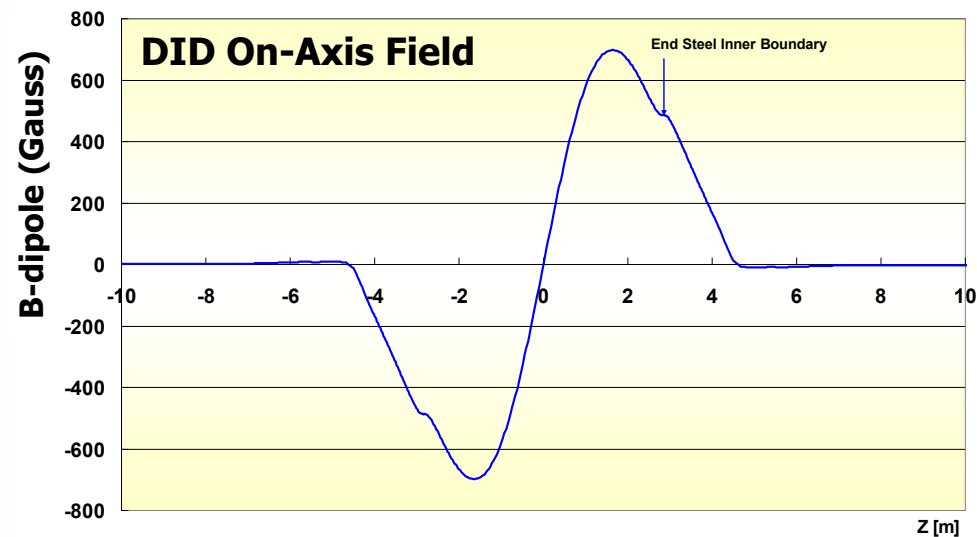
# Detector Integrated Dipole: RD8

- Beams cross at an angle, so they see a transverse B-field component
- A Dipole-Integrated-Detector (DID) facilitates a crossing angle
  - “Saddle-coil” dipole wrapped onto outer support cylinder of solenoid
    - Compensation of field
    - Study of stresses in DID



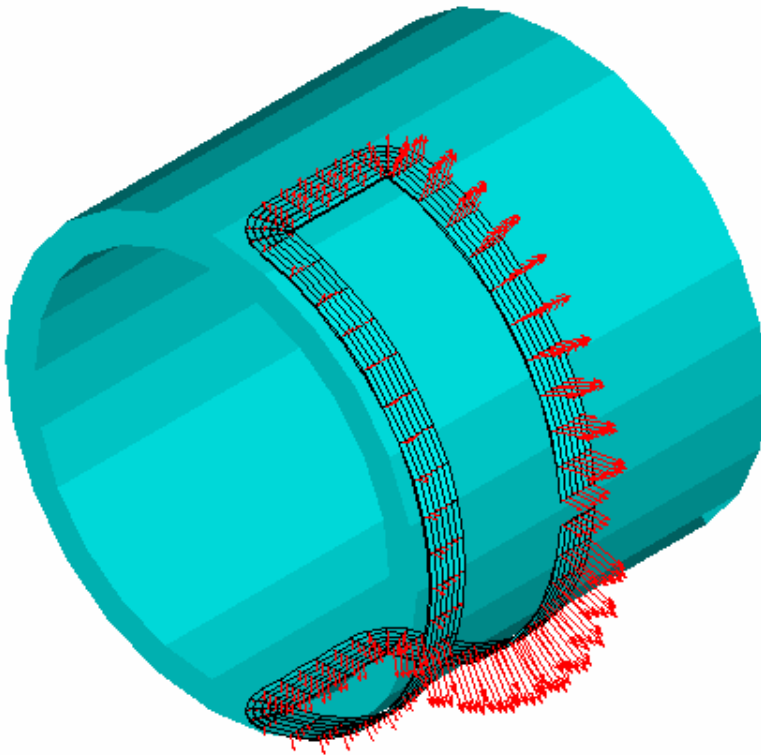
Inner radius of dipole coils is 1 cm greater than support cylinder radius

Forces are large



# Detector Integrated Dipole: RD8

- **ANSYS calculation of total stress on DID**
  - **Forces are large**
  - **Radial forces in inner leg of one saddle are balanced by those on adjacent leg of other saddle. That may mean that an engineering solution may be readily developed maybe manageable**
  - **Axial forces are large but appear manageable**

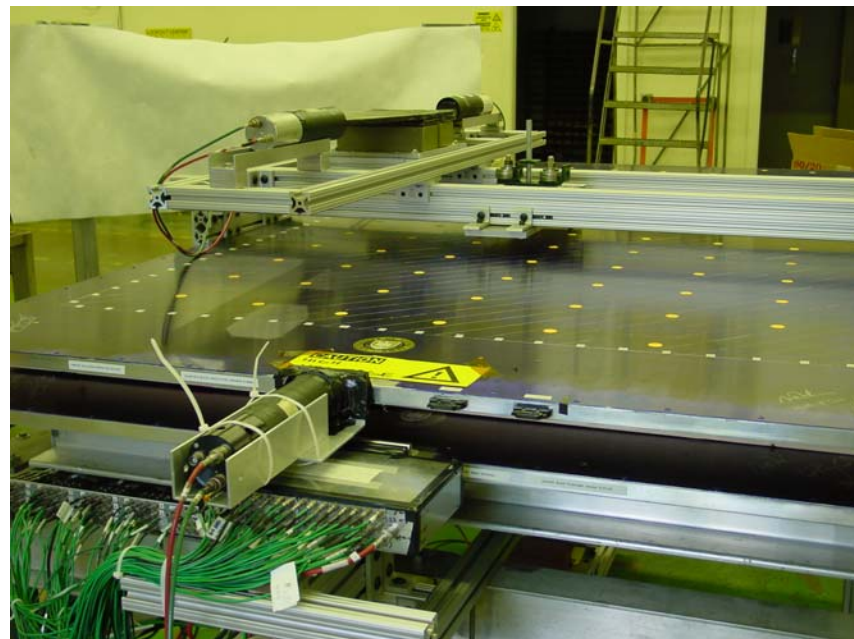


**For real conceptual design, closer look at cooling coils and DID on outer support cylinder of solenoid required; also need conceptual design of DID conductor and winding approach**

- $F_x = 400\text{K lbs}$  (radial, summed)
- $F_z = 1754\text{K lbs}$  (axial, summed)

# Muon System: RD9

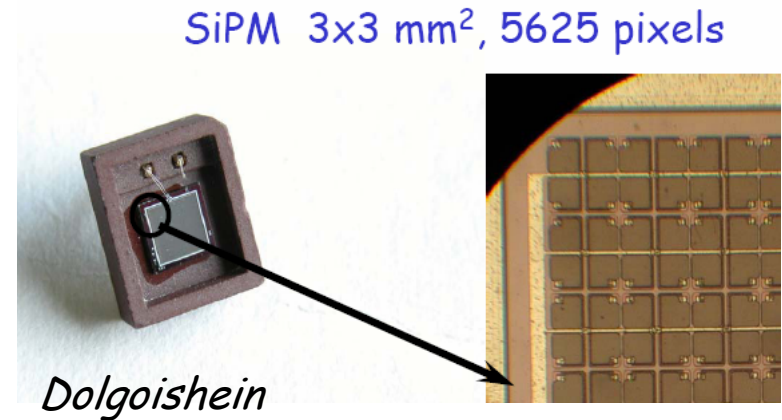
- **Scintillator based muon tracking system**
  - **Scintillator strip panels with Multi-Anode PMT (MAPMT)**
    - MINOS style scintillator from Lab 6
    - Chamber 2.5 m x 1.25 m
    - Strips: 4.1 cm X 1 cm
    - HPK MAPMT 16 or 64 channels
    - 4mm X 4mm pix / 16 ch
- **Development towards:**
  - **Construction of 8-12 planes for test beam with NIU tailcatcher**
  - **Performance comparison of Muon and HCal with HCal only**
  - **Optimization of WLS dyes and scintillator**
    - Fast timing
    - Maximum light and signal output
  - **Development of associated software**
    - maximize muon efficiency and purity



- **Cosmic Ray setup in Lab 6**
  - **Single and dual counter planes**
  - **2" thick Pb absorber above and below plane**
  - **2 trigger counters above and below plane**
  - **Channels readout with single PMT (top plane) and MA-PMT (bottom plane)**

# Muon System: RD9

- Explore optimization of readout in terms of properties of components but also completely different readout techniques
- Exploit overlap and synergies with other detector systems
  - **Faster decay time WLS fibers with better matched QE**
  - **Silicon Photo Multipliers (SiPM)**
    - Pixel Geiger Mode APDs
    - Gain  $10^6$ , bias  $\sim 50$  V, size  $1 \text{ mm}^2$  with about 1000 pixels
    - QE x geometry  $\sim 15\%$
    - Also being considered for scintillator HCAL readout
- Comparative studies of different development/adaptation of front-end readout electronics for MA-PMT's, Si-PMT's, Si APD's for  $\sim 128$  channels
  - **Test beam at Fermilab with NIU tailcatcher will employ SiPM readout**



# Synergies

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- **Collaboration with industry through SBIR/STTR grants**
  - **SBIR = Small Business Innovation Research grant**
  - **STTR = Small Business Technology Transfer grant**
- **There are many areas with clear synergies between the dedicated ILC detector R&D efforts and other projects at the laboratory**
  - **Understanding of hadronic shower development**
    - Particle production for Minerva, MINOS, MIPP, ...
  - **Tailcatcher efforts at NIU**
  - **Test Beam**
  - **Inter-laboratory projects**
- **Replacement vertex and tracking detectors for the LHC experiments**
- **Upgrade detectors for SLHC**
- **Regional Efforts in Calorimetry**
  - **ANL: digital hadron calorimetry with RCP readout**
  - **NIU: analog hadron calorimetry with scintillator readout**
  - **U of Chicago: readout electronics for hadron calorimetry**

# SBIR

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- **SOI detector R&D carried out in collaboration with American Semiconductor, Inc. (ASI)**
  - **Located in Boise, Idaho**
  - **<http://www.americansemi.com/>**
  - **Has access to state-of-the art 130 and 180 nm processing facilities**
- **Proprietary SOI *Flexfet*<sup>TM</sup> process technology**
- **Submitted three STTR proposals in collaboration with Fermilab:**
  - **LHC radiation hard SOI**
    - ASI proposes a feasibility demonstration for the development of a new low-mass, high-speed, radiation-hard pixel sensor for LHC and Super LHC use. Device thickness is expected to be 300 microns or less and have resolution speed in the range of 25ns and radiation tolerance in excess of 10Mrad. Development of the device would utilize ASI's proprietary AS183SOa Flexfet<sup>TM</sup> 0.18um Triple-Metal SO-CMOS Sensor Option process flow utilizing Silicon-on-Insulator (SOI) device architecture ...
  - **ILC SOI device**
    - ASI proposes a feasibility demonstration for the development of a new low-mass, high-speed, radiation-hard sensor for ILC use. Device thickness is expected to be approximately 50 microns and have resolution speed in the range of less than 50 microseconds as well as radiation tolerance in excess of 100 Krad ...
  - **Radiation Hardness**
    - ASI will study the characteristics of existing Flexfet<sup>TM</sup> devices with non-enclosed geometries ... up to ~50Mrad

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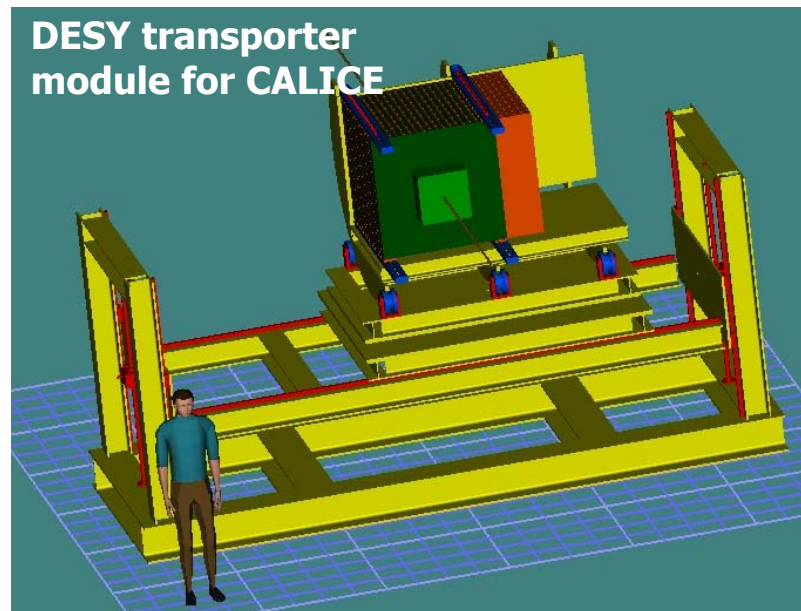
# Testbeam

- Testbeam facility at MT6 set up, commissioned and supported
- Testbeam configuration
  - Beam parameters:
    - Momentum between 4 and 120 GeV
    - protons, pions, muons, electrons
    - Resonant extraction
    - Variable intensity
    - Low duty cycle
  - Usage:
    - 14 MoU's for Test beam
    - 8 Completed tests
      - BTeV Hybrid Pixels (FNAL)
      - Belle MAPS (Hawaii)
      - CMS Pixels (NU, Purdue)
      - DHCAL (NIU, ANL)
- A design study has been initiated to improve the beamline at MTest to better meet the requirements of the ILC community
  - Move target further downstream and duplicate beamline of MCenter
    - Lower momenta accessible
    - Cleaner beams



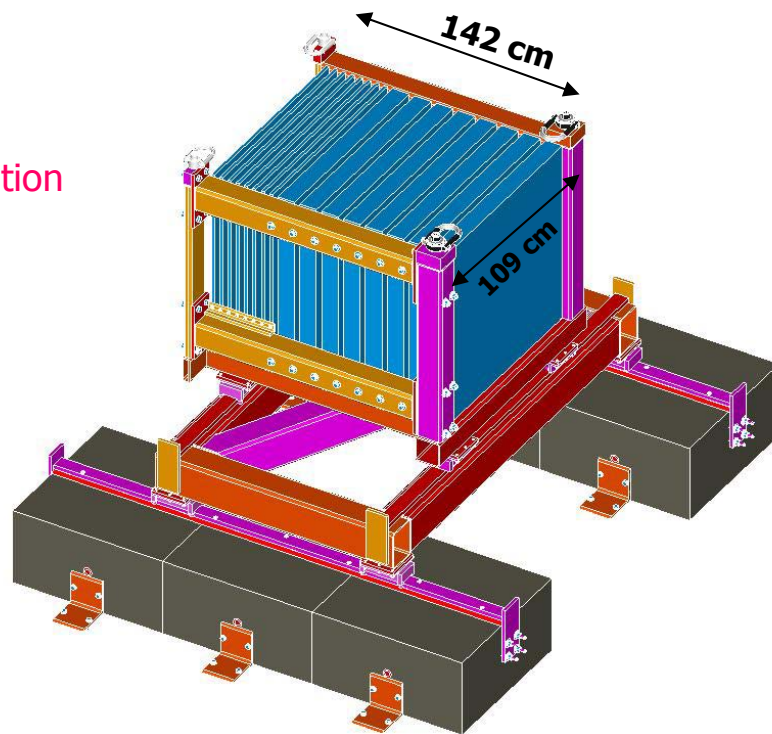
# Testbeam for ILC

- **Proposal for multi-year testbeam program for study of high performance calorimeters for the ILC**
- **Tentative schedule:**
  - **early 2006: Muon system tests**
  - **early 2006: RPC tests**
  - **summer 2006: Muon Tailcatcher and RPC readout**
  - **tentative: summer 2007: CALICE full EM and HCAL (scint + RPC)**
- **The laboratory is committed to supporting the current testbeam**
- **The potential of the test beam efforts could by far exceed the scope currently foreseen**
- **However, integration with the ILC community and building coherent study program between ILC calorimetry efforts, testbeam results from other experiments and results from other physics experiments at the laboratory is challenging on many fronts**



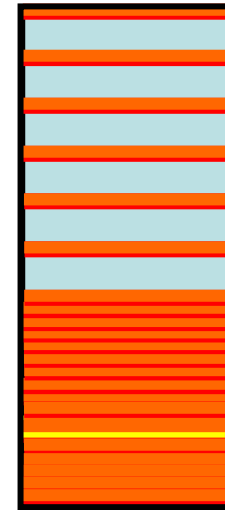
# Tailcatcher

- For all ILC concept detectors, the calorimeters are inside the coil. The resulting calorimeters may be 'thin'
- NIU is building a so-called tail-catcher
  - **Sample the tails of the hadronic shower**
    - Study hadronic showers and validate simulation
    - correct for leakage, effect of solenoid
  - **Use as muon detection system**
- **Configuration of Structure**
  - **Fine and Coarse section (8 layers each)**
    - 2 (10) cm thick steel (weight ~ 10 tons)
  - **Active medium consists of 16 cassettes**
    - Scintillator Strips, 5 mm x 5 cm
    - Alternating xy-orientation
    - Readout with WLS Fiber and SiPM
      - Common readout with HCAL
- **All mechanical design work for the tail catcher is carried out by Fermilab**
  - **Moveable platform**
  - **Absorber sections of calorimeter; work has started this week**
- **Readout is with Si-PM's**
  - **Fermilab mechanical engineering help with layout of active planes of scintillator based analogue HCAL**

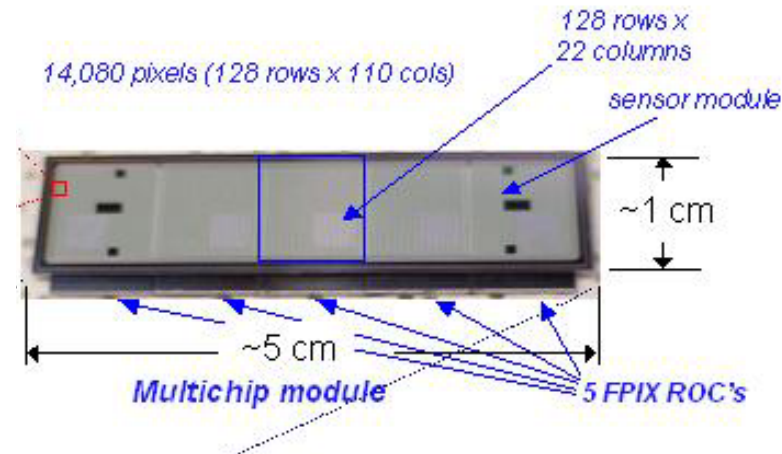


# FNAL - BNL Interlaboratory Project

- **Phenix upgrade calls for a "Nose Cone Calorimeter"**
  - **Silicon-Tungsten,  $0.9 < |\eta| < 3.0$**
  - **Three longitudinal sections**
- **Compare ILC EM Calorimeter**
  - **30 Layers, 2.5 mm thick W,  $5/7 X_0$  / layer**
  - **5 mm hexagonal pixels**
  - **1mm gaps for Si and readout:**
  - **Readout with kPix chip**
- **Phenix forward pixel detector (under discussion)**
  - **Based on BTeV FPIX design**
  - **build two 4-plane pixel telescopes**
  - **Sensors are BTeV pixel sensors**
  - **Readout using BTeV FPIX chip**

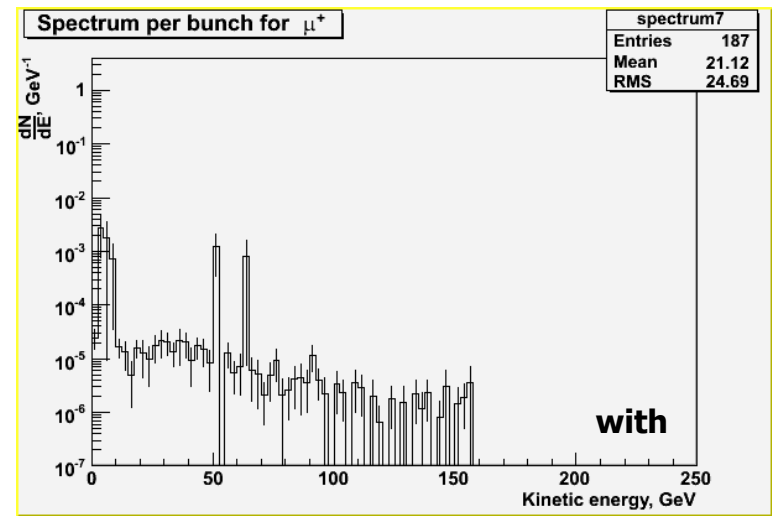
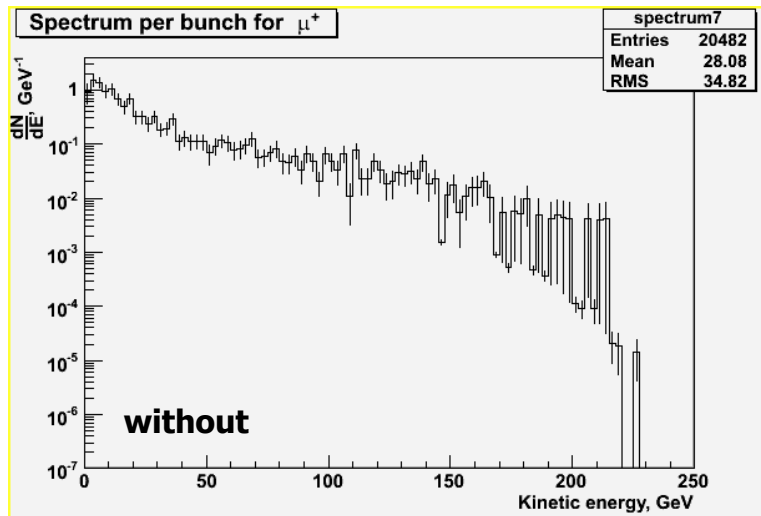


- **Hadronic**  
Six layers, 16.6 mm W  
Si pads  $1.5 \times 1.5 \text{ cm}^2$
- **$\pi^0/\gamma$  identifier**  
Two layers of Si  
1.9mm x 6cm strips
- **EM:**  
16 layers, 2.5 mm W  
Si pads  $1.5 \times 1.5 \text{ cm}^2$



# BDIR - MDI

- Interaction with group in Accelerator Division working on backgrounds in machine and collision halls (Beam Delivery and Interaction Region / Machine Detector Interface)
  - Simulations are done with the MARS15 code
  - Model describes the last  $\sim 1500$  m of 20-mrad  $e^+$  line
  - The model includes beam elements, collimators and tunnel
- Backgrounds in the SiD detector (2800 bunch/train,  $2 \cdot 10^{10}$   $e^+$ /bunch)
- Particle spectra in the detector with and without spoilers in the beamline



# Synergies

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- **Collaboration with industry through SBIR/STTR grants**
  - **SBIR = Small Business Innovation Research grant**
  - **STTR = Small Business Technology Transfer grant**
- **There are many areas with clear synergies between the dedicated ILC detector R&D efforts and other projects at the laboratory**
  - **Understanding of hadronic shower development**
    - Particle production for Minerva, MINOS, MIPP, ...
  - **Tailcatcher efforts at NIU**
  - **Test Beam**
  - **Inter-laboratory projects**
- **Replacement vertex and tracking detectors for the LHC experiments**
- **Upgrade detectors for SLHC**
- **Regional Efforts in Calorimetry**
  - **ANL: digital hadron calorimetry with RCP readout**
  - **NIU: analog hadron calorimetry with scintillator readout**
  - **U of Chicago: readout electronics for hadron calorimetry**

# Peripheral Support

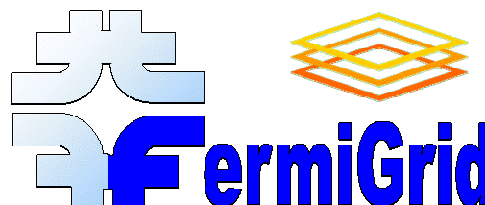
- **Simulations**

- **Activities are accompanied by simulation efforts to optimize the design**
- **Fermilab Computing Division has installed the Simulation for the Linear Collider (SLIC) framework on Fermilab cluster**
  - **SLIC is core North-American simulation package**
    - dependencies: Geant4, Xerces, GDML, LCDD, LCIO, LCPhys
    - <http://cd-amr.fnal.gov/ilc/slic.shtml>
- **Farmlet available for simulations at [ilcsim.fnal.gov](http://ilcsim.fnal.gov)**

- **Grid**

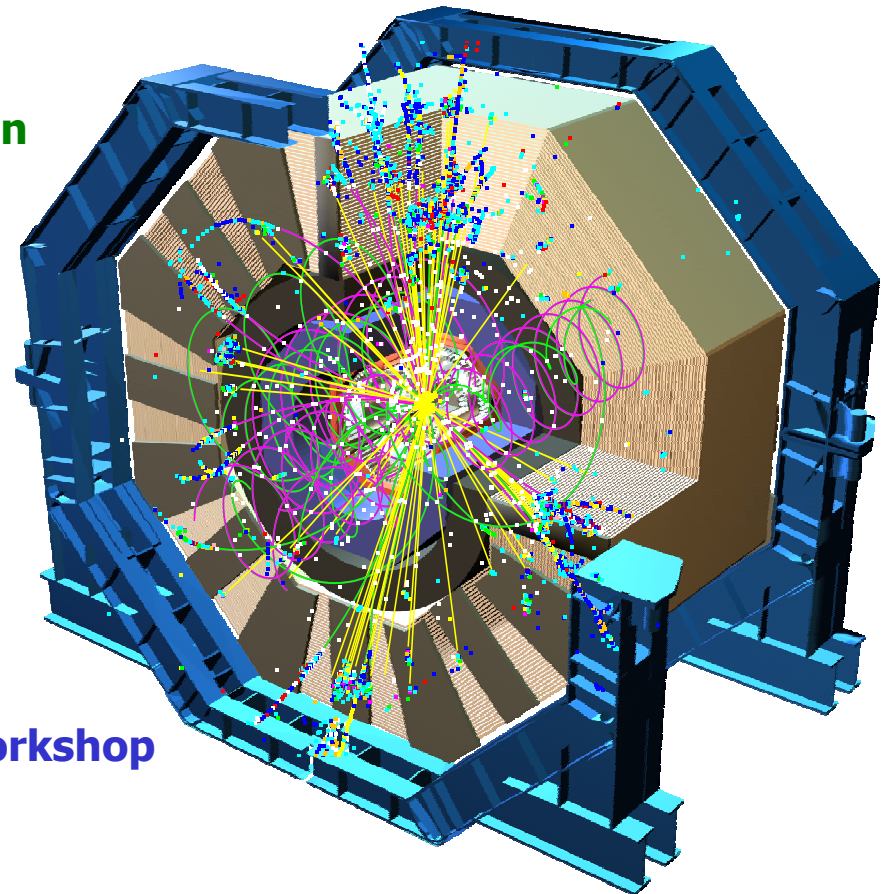
- **Active ILC community utilizing**
  - **Enabling Grids for E-Science (EGEE)**
    - European Union sponsored
  - **LHC Computing Grid (LCG) infrastructure**
- **Virtual Organization (VO) defined: “ILC”**
- **All Grid infrastructure made available to the ILC community at Fermilab**
  - <http://grid.fnal.gov/>

**EGEE**  
Enabling Grids  
for E-science



# SiD Detector Design Study

- Most of the R&D carried out is detector independent
  - Some performed in collaboration with other detector concepts
  - Results should be applicable and transferable to any detector concept
- Some studies, however, are SiD detector specific
  - Optimization of detector design
  - 5T solenoid design
  - Vertex detector - beampipe design
  - ...



- Fermilab is hosting a SiD Detector workshop  
Dec. 16-17

# Projects and Participation

	ILC R&D Project	Participants
RD1	Design Vtx/Trk Detector	S. Burdin, <a href="#">B. Cooper</a> , M. Demarteau, J. Howell, M. Hrycyk, K. Krempetz, R. Lipton, Y. Orlov, M. Weber, Y. Xi
RD2	MAPS, CMOS	D. Christian, M. Demarteau, J. Hoff, S. Kwan, R. Lipton, A. Mekkaoui, W. Wester, <a href="#">R. Yarema</a>
RD3	MAPS, 3d - SOI	D. Christian, M. Demarteau, J. Hoff, S. Kwan, <a href="#">R. Lipton</a> , A. Mekkaoui, W. Wester, R. Yarema
RD4	Hybrid Pixels	<a href="#">D. Christian</a> , M. Demarteau, J. Hoff, S. Kwan, R. Lipton, A. Mekkaoui, W. Wester, R. Yarema
RD5	MDI, beampipe	<a href="#">B. Cooper</a> , K. Krempetz
RD6	PFA	D. Denisov, <a href="#">A. Para</a> , E. Yu
RD7	DHCAL	D. Denisov, J. Hoff, A. Mekkaoui, <a href="#">R. Yarema</a>
RD8	5T Solenoid	<a href="#">R. Smith</a> , B. Wands
RD9	Scint. Muon	D. Denisov, <a href="#">G. Fisk</a> , C. Milstene
	BDIR - MDI	A. Drozhdin, M. Kostin, <a href="#">N. Mokhov</a>
	Physics	M. Carena, A. Freitas, A. Juste, A. Kronfeld, C. Milstene
	Simulation Support	L. Garren, P. McBride, G.P. Yeh

- participation is still thin (about 9.5 FTE), but is getting stronger
- Actuals for FY05 for PPD: 8.1 (includes technicians)

# Issues

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- **There are two distinct and crucial roles the laboratory can play for a leadership position within the ILC detector community**
  - **'Local Role': R&D carried out by the laboratory and in collaboration with other groups**
  - **'Global Role': Role as a host laboratory creating a global center, an inviting environment for ILC collaborators independent of detector concept**
- **'Local Role'**
  - **There needs to be an intellectual involvement in the ILC detectors**
  - **Clear competition between the Tevatron program, the LHC and the ILC**
  - **Need to weigh the relative priorities of the various programs**
  - **Need to arrive at a balanced program**
    - **Fermilab should be (is?) a natural place to have a well-balanced program between the ILC, Tevatron and also the LHC efforts, including the users.**

# Issues cnt'd

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- **'Global Role'**
  - **Fermilab has established itself as a lead laboratory, on a par with SLAC, DESY, KEK, in accelerator areas**
    - SMTF (Superconducting Module Test Facility) to name one
  - **Fermilab should also play a global role for detector R&D and establish a coherent program for detector studies**
    - Parallels between SMTF and the Fermilab Test beam?
      - Create a test beam program for the whole community?
    - What role do we want to play and can we play that role with CALICE ?
    - Test beam is attractive to the user community, but duty cycle is low.
    - What is a good balance?
  - **The US-CMS community has established the LPC. Should we introduce an IPC (ILC Physics Center) or an LIPC based on the synergy between the LHC and ILC?**
  - ...

# Summary

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- **ILC R&D at Fermilab gaining momentum**
- **Focal points:**
  - **Vertex and tracking design, both mechanical and electrical**
  - **Calorimetry**
    - PFA algorithms
    - Mechanics and readout of particle flow calorimeter
    - Complex issues; possibilities still being explored
  - **Muon Detection and software development**
  - **Solenoid**
- **Obvious synergies with existing program; needs careful orchestration; obvious regional synergies**
- **Should Fermilab play a stronger local and global role for ILC detector studies and what is the best way to proceed ?**
  - **It would help the effort enormously if an opening would be created dedicated to the ILC**